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ABSTRACT

This document consists of two separate papers, by different authors, that discuss (often duplicating each other) the Microelectronics Education Program (MEP), a program which was designed to help children understand new technology and its effects on society and to encourage teachers to use the new technology in improving their teaching effectiveness. The program uses a combination of nationally and regionally controlled programs coordinated by a national plan. Regional activities include information centers for teachers, an inservice training program for teachers in all subjects and at all levels, and curriculum development, including the preparation of new computer programs and other teaching materials. These three areas are mirrored in national projects. The program emphasizes four main domains: electronics and control technology, computer studies, computer based learning, and communication and information studies. Special education is also being addressed. Three major schemes are now complete or under way to help schools purchase equipment, all of them involving government funding of half the price while schools pay the other half. MEP has also produced inservice training packages. The program has thus been developing approaches, designing teaching and learning materials, and providing training in the use of equipment, as well as working with the final element, transforming the classroom itself into an environment that is re-arrangeable, open-ended, and exploratory. (LMM)

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MICROCOMPUTERS IN MODERN SCHOOL TEACHING

THE IMPACT OF MICROELECTRONICS ON THE CURRICULUM

Near where I live is an area which was once devoted to sheepfarming up to the middle of the last century. With the growth of the industrial revolution, there was demand for energy, and coal was the obvious resource. These same fields that once fed sheep were dug up for underneath was a rich source of this fuel. Some twenty years ago, the coal extracted, the area was reclaimed, and now there is a factory producing chemicals by highly automated means and an estate of houses, many with small businesses operating from them. I tell this story to illustrate the changes that have and are occuring in our society, changes to which education has to respond. In facing the information age, we must not just think of preparing children in an understanding of computers and skills in operating them, important as that is. Equally essential is the need to help them prepare themselves for working and living in our changed society and relating to each other under circumstances that incidentally are changing very rapidly. Thus, the other concern is the total school curriculum and how that has to be amended to suit the needs of our children.

The revolution caused by the new technologies has hit Britain fast and the changes we are seeing in home and work environments, although rooted in developments of the last thirty years, have really accelerated during the last four years. With the forecasts of technological developments that we have already heard, the prognosis is for greater and faster changes, and in education we have to learn to adjust and absorb them, to make use of them where appropriate for the benefit of our teaching methods and help our children to understand them so that they can cope with society when they leave school. In this paper, I want to outline some of the approaches that we have been making in Britain in response to this situation, a response which is clearly different from that in any other country and which so far has been very successful in meeting its aims.

It was in 1980 that the government announced a project for education to meet the challenge of the technology, and I was appointed to lead what has become known as the Microelectronics Education Programme or MEP. While initiated by the government through the Department of Education and Science and receiving its funds from it, the Programme has been given a relatively free hand to approach the problems in its own way, and that sense of independence continues to be very important in encouraging teachers to work closely with us. MEP formulated two main aims to guide our decision-making for the activities we were to initiate:

(a) to help children understand the technology and its effects on society

(b) to encourage teachers to use the technology in improving the effectiveness of their teaching.

It will quickly be obvious to you that this means that all curriculum subjects will be affected by our activities, science and maths of course but also history, geography, music and english. I am sure you will notice as well that children of all ages will be involved, from five years old to 18. Indeed the five to eleven year olds are some of the most responsive of all. So quick are they at acquiring the simple skills of controlling the machine and so fearless are they of the equipment that they also help to give their more reluctant teachers the necessary confidence.

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Therefore you will have appreciated that the Programme is concerned with meeting its aims in all subjects of the curriculum and with children of all ages. In addition, it must be emphasised that it is also concerned with children of all abilities. As we are not concerned solely with turning children into bright computer scientists - more of which later - we are not targetting our work on the clever children alone. Rather, this is for all children, for all are going to live in a world dominated by this new technology and they all need to adjust to it. It is also true to say that this technology can bring out abilities, interests and enthusiasms which have been ignored by other areas of study, particularly in work with the technology itself.

There are over 400,000 teachers in Britain, and the question we faced was how to reach them all and make them relate to the work of the Programme. You may be aware that while there is a government department which gives guidance on education, the actual schools and teachers are organised by 109 local authorities, each with an independent viewpoint. With their co-operation, a word you will hear many times in this paper, we have organised them into 14 regions for the purposes of the Programme. This has given us the opportunity to get closer to the teachers in every part of the country for there are MEP activities scattered around in every one of these regions.

More of this in a moment. Thus the strategy is based on an almost even split between activities that are initiated and controlled nationally by the directorate of the Programme and those that are operating in the regions to a nationally set list of aims, and monitored and co-ordinated by the same national leadership. To make this succeed, it requires a coherent plan and a co-operative approach.

The regional activities are divided into three parts. First, there is the Information Centre with staff to issue newsletters, show visiting teachers equipment and a wide variety of teaching materials in many media, help them over their problems and give them instruction, but above all keep them well-informed about curriculum developments and new software and devices in their subject areas.

Secondly there is an in-service training programme for teachers in all subjects and at all levels. This Programme is divided into four domains which I shall describe later, and in the first full year of operation, over 24,000 teachers have been on the courses offered. These range from two to ten day courses. Each is run in the region by regional staff so that local needs and interests are covered but the main elements of the courses are planned and developed by national co-ordinators. The aim is to concentrate on teachers in the regions who will then go on to train their colleagues so that the whole approach cascades down from the national initiative to the classroom itself. We are not in control of this last layer, but a rough estimate suggests that over 70,000 teachers will now have met some training from this approach. As for those regional staff, they too go on regular updating courses to keep them abreast of the latest developments and new materials.

The third of these regional activities is curriculum development, the preparation of new computer programs and other teaching materials, again arranged to a clear national plan of needs. This builds on the natural skills of the teachers and advisers in the regions who know what they want in the classroom, and thus here are more small groups of people involved in MEP work and generally supporting and spreading its message around the country. This increases widely the number of educationists who are co-operating with us to ensure the work succeeds.

Each of these three areas of activity are mirrored in national projects as well. Thus we provide central information in newsletters and on electronic systems like our Diamond discs which go out for our word processor network, and also pages on Prestel, the national viewdata system which schools are increasingly able to access through their computers.

For in-service training, we have a considerable project being prepared by the Open University. This will generally reflect much of the in-service programme and will be particularly valuable for those who find it difficult to attend courses or who are not very happy about attending them. The national software development units are now well established, and more are being created. They produce large numbers of computer programs, again to a national plan of work, and they reach very high standards of quality and classroom value. The important point about all these programs is that they are carefully planned with teachers much involved so that they fit the actual classroom needs.

Let me turn now to the coverage of the Programme and also its products to date. I am going to do this by talking about each of the domains in turn, but before doing so, let me re-emphasise the importance of the teacher training aspects. These materials and devices do not work to their maximum effect unless the teachers using them are trained in their value within the classroom situation. This is the conclusion from all our experience, and it is the reason behind all our emphasis on careful teacher training. One further point - all these domains do have overlaps with each other.

The first domain is electronics and control technology. In our view, all children must have some experience and understanding of this new technology so that they can deal with it in their future lives. This can begin effectively at 9 and 10 years of age, so that children begin to appreciate simple devices, the logic which arranges elements to perform specific jobs, and create them for themselves. This 'microelectronics for all' approach has led to some very exciting classroom work. Some is theoretical through filmstrips, simple kits and videotapes, but children really get involved and reach understanding when they start making items. Some approach this through breadboarding with children knitting together circuits that work. Others start from carefully planned boards with inputs and outputs that the children can work on experimentally. Each leads to further understanding of the different ways in which the various elements can be linked to achieve different results, all in the process of using programmable devices to achieve particular controlled results. The end product may be traffic lights or it may be a robot arm, but the process is the same in both. From the skill point of view, the children learn the fundamentals of problem solving.

With this as a basis, children may choose to develop further knowledge of electronics and control, and further devices and teaching materials have been developed to enhance that work. On the other hand, they may wish to concentrate on other science and technology subjects. Is it engineering and design? A computer program through which the children can design a shape, and then the computer can control a simple lathe and cut that same shape out of polystyrene. Is it physics or chemistry? A new laboratory instrument which merges many separate measuring, monitoring and controlling devices in one to record and replay many experiments in a modern way and help the children draw real scientific conclusions. Is it biology? Devices to monitor and measure temperature, humidity, movement and chemical change to reveal insights in the science of life, and display them in new ways. All the devices are microprocessor based; all help children develop understanding of scientific truths at the same time as absorbing the concept of control.

Our second domain is computer studies. For all children some understanding of how the computer works as a system, and the various elements of language and operation, are essential. There is nothing quite like using control to help children overcome initial anxieties and develop confidence. That is why we developed the buggy with its range of software to get children excited, but also through the range of programs to develop understanding of the elements of control and what the computer itself is doing. From this general background, some children will move on to more detailed studies. A range of texts have been prepared to help them grapple with the computer as a system, simple programming and most important its range of applications in society and in industry. Videotapes, books and case studies have been created to illustrate and deepen their knowledge of this all pervading device, above all giving them confidence and understanding of its use. As they get more experienced, more complex control options are opened up to them through kits and they begin to explore examples of database management as well. All provide a basis for stimulating interest in a career of computer science, but this degree of detail is only for a few.

In the electronics domain, we have been largely creating a curriculum and devices to help to teach it, whereas in this domain, computer studies, the general curriculum was established, and we have set out to prepare materials and approaches to help children learn in an interesting and practical way.

Our third domain, computer based learning, is different again. Here we are concerned with computer programs that the teacher can use to help children learn any subject in the curriculum at any age. We have programs for 3, 4, and 5 year olds and programs for 16, 17 and 18 year olds. They fit any subject too, languages or science, music and art or technology. Before looking at the types of program, let me just say how important we feel the packaging and presentation is to the teacher. The program must be capable of secure and safe storage under normal classroom conditions. It must also, and I want to stress this, have good, detailed documentation, not in the technical sense, but in the educational information it gives, for example objecives, age range, what the children must know before they use it, what they can go and do afterwards to consolidate and expand the learning that has taken place.

The easy and natural response that teachers make towards the computer is that the programs can question and test knowledge, so-called drill and practice. Now, in our opinion, there is no reason why these should not be developed by a teacher for his own use, and various content free programs have been prepared to help them. That is material for the teacher to develop for the children in his particular classroom, not for a national Programme. These programs do not begin to exploit the exciting learning opportunities of the computer. Instead our emphases are on simulations, models and conjectural programs, encouraging children to explore topics and how they work, and learn as a result. Children must be able to alter parameters or feed in their own ideas and react to the results by trying other approaches. They must draw conclusions and deduce concepts from these experiences. Exercises they undertake must bring out deductive thinking, exploit and manipulate the knowledge they have and force them in to decision-making routines. We want to encourage children to adventure in the programs to different degrees and discover meanings. For the teacher, these cause more challenging thinking and pedagogic problems, for they mean that they have to help the children work and deduce through careful leading and judicious questioning, but the rewards at all ages are more excited and stimulated minds. The inarticulate learn to express themselves; the unaware find insights.

You will appreciate my enthusiasm. Screen design is obviously very important too as is the way the simulation works, but most important of all is that the learning psychology and the suitability for the prepared teacher and the curriculum is right, and it is that with which we have taken care. While many of the programs are totally self-standing, it is interesting to see how teachers feel that a program is just one resource among others, and thus there is a great deal of associated learning going on away from the computers in other parts of the classroom, often with the children working in groups. The program is just one part of a total learning experience. MEP is much involved in developing these extra resources as well as the program itself.

Our fourth domain is communication and information studies. One half of its work is very obvious and clearly relevant, the understanding and use of word processing and other business studies work. We have developed materials which are specially designed for teaching purposes which can be used at any age. For it is already clear that teachers of many subjects find word processing for themselves, and for the children they teach, can be very useful. Together with all other aspects of electronic communication systems which children will find a major feature of their future, this forms one part of the work of this domain.

The other part, and in many ways some of the most significant aspects of the whole approach of MEP, is the area of information studies. You will all be familiar with information retrieval systems, and the Programme has fostered several approaches. These range from a system for young children to more sophisticated work for the older ones. Much early learning is spent on the collection, organisation and presentation of factual information, and information retrieval systems are colourful and exciting ways in which children can get their facts together, overcome the boring bits of sorting and come rapidly to groupings which can lead to deductions, planning and thinking. In our opinion, this introduction can start at even four and five years, particularly with pictorial presentations of the results. When they get older, the systems have to be more complex, but then they are dealing with larger and more sophisticated bodies of information and looking for deeper insights and understanding. A database of a census can be very large, but the information that children can deduce from its rapid sorting can reveal very interesting and educationally useful knowledge.

This is still only the beginning. Large databases are increasingly on tap at the end of a telephone line. While each might have its own protocols, the principles of access and search are the same and these are what children need to appreciate so that they can cope with developments in the future. Their microcomputer is the terminal from which very large quantities of data can be accessed and explored as necessary. But the core of this work is the nature of information itself. What is it? How does it arrive? How is it created? What questions do we ask in order to get what we really need? Most important of all, what do we do with it when we have the information? These are the fundamental educational issues and we are now working hard on materials that help children work towards the answers. As will be clear to you, these are issues that affect every subject in the curriculum, and so the work we do must help in each and every discipline. In the classroom itself, the changes will be profound, for it is not the information-giving role that will be the main purpose of the teacher but rather the information-using aspects. This is a change to the core of our understanding of the purposes of education.

Those then are the main domains of the Programme, each approached broadly and affecting all aspects of the learning environment and all parts of the curriculum. One further sector is receiving much attention, and that is special education. I had better explain what is meant by that. A number of children are slow learners or may even be mentally backward, and a small number suffer from physical handicaps, blindness, deafness or muscular problems. All these collectively are educated through special education schools or units. Programs for them work at a more patient and lower level of sophistication, helping them to practise skills and re-inforce knowledge that they have gained. A number of programs have been developed for these children, and some of those aimed at younger children can be specially adapted. MEP is also working with some simple devices to try and help these children manipulate and work in their environment.

The approach to special education is the same as the rest of the Programme. We have information centres called SEMERCs that keep teachers informed and provide exhibitions of ranges of appropriate materials. They are also involved in stimulating co-operative work between the teachers. There are also teacher training activities which help to brief the teachers and keep them up to date with the latest developments, and also there are projects throughout the country where materials and devices are being conceived, created and tested in the classroom. The number of children who need this help is not very large, but the affect on them, their ability to communicate, work and join in with the rest of society is profound.

I am sure you will have noticed that up to now I have hardly mentioned equipment. Only in the electronics domain has it figured significantly. The theme of the Programme has been to answer the questions that have been posed by educational needs, the requirements of teachers and the curriculum initiatives that have underwritten them. However MEP has not ignored the equipment side, and by working in co-operation with another part of the government, the Department of Industry, it has encouraged the distribution and use of computers.

Three major schemes are now complete or under way to help schools purchase equipment, all of them involving government funding of half the price while schools have paid the other half. Only one computer or peripheral system has been on offer to each school in this way and they have been able to choose from two or three British machines, Research Machines, Acorn BBC and Sinclair, all of which are available throughout the world. The programs we have written work on these machines, but many are also available on Apples and Pets. Our ethos has been to write for one machine and rewrite for the others so that the programs take advantage of the particular specifications that each offers. In school use each of these computers has proved very successful and now networks are being established between groups of them. While the government offer only referred to one machine, the impact has been very considerable. Schools for the 11-18 year olds have at least five now and several have 20 to 30 computers, while the smaller schools for the seven to 11 year olds have one to two. Considering that resources for schools are limited, this is a very rapid uptake in a period of about only two years. Teachers must feel they are important and useful to have put such a priority on obtaining the equipment.

In supporting the issue of this equipment, MEP also produced in-service training packages to go with them. Teachers not only made use of these materials to help them understand the equipment but they also went on courses of two to four days to discuss and work with them. They have already reached some 15,000 teachers and the younger children's schools scheme has only just started.

You will notice the wide range of materials in these packages, books, machine guides, audiotapes, overhead transparencies, tape slides and of course computer programs. The tutors who take the courses that the teachers attend also have carefully prepared kits of materials to use in their own personal way but based on a carefully designed national scheme.

Thus the Programme has been developing approaches, teaching and learning materials, and equipment. The final element in the complete impact on the school is the classroom itself, and we have been working here as well. A computer classroom is not just a place where children learn computer studies and are taught by a teacher dictating knowledge. It is a place where children can come and explore all the many ways in which this equipment can support learning in very many subjects, and thus such a classroom should be completely re-arrangeable, open-ended and exploratory. The design we have established meets all these requirements and provides a pleasant and exciting atmosphere in which to learn.

In a paper of this length, it is not possible to give more than a hint of the philosophies behind the MEP operation. We are obviously producing great quantities of tried and tested materials in a wide range of subjects and media, and in doing so, we have set a large number of wheels in motion for more and more such projects. In what I have discussed, and in the pictures I have shown, you have been given a small taste of the operation. I hope you have gained the impression also that all this work, although funded and sponsored from government funds, is firmly based in the curriculum and teachers needs in meeting the learning requirements of children. There is a carefully plotted and coherent set of plans for the development and production of these materials which fit certain curriculum aims and these are nationally developed. The important issue for the teachers is that they can add to this approach and interpret it in a style which fits the particular group of children with whom they are working.

You will have noticed also that the Programme is comprehensive. We came to the conclusion, early on, that it was not sensible to concentrate on only one aspect, computer studies for example, for the impact of this technology was pervasive throughout the curriculum just as it is throughout society. It was also producing major changes in the way in which subjects could be approached and learnt, and in the attitudes of the children. So you will have seen that we have covered all ages and all subjects. We have also interested ourselves in the teachers, the curriculum, the materials, the equipment and even the classroom. Affecting one without involving another aspect again means that you omit areas that could well prove to be the final constraint in preventing a teacher taking the value of the technology into his work.

At the beginning of this paper, I mentioned the word co-operation and I want to return to it now. While the Programme itself is a nationally directed operation, you will have gathered that the work is a joint participation between the teachers, our regional staff, many small working groups and the national directorate. It is not just focussed around the capital London - indeed the directorate is based in the North of England in Newcastle - but involves the whole country. Nor are the projects themselves only funded and supported by the education system. We have many joint activities with large and small companies in all parts of our work, another example of co-operation. To distribute and market our products, we have worked with many other commercial concerns, both large and small, publishers, manufacturers and software houses. They are co-operating with us in taking the materials, packaging them in our styles and distributing them all round the world. We too are working with other companies who have developed their own products, and where we think them of value, we are putting them in our information centres and on our courses and discussing how effectively they can be used.

This sense of co-operation has transformed the efforts of the Programme, and made it possible to develop more and penetrate deep into the heart of the education system. Together, the impact has been greater, and all have gained from the strong educational push and analysis that has accompanied it. Several of the materials are available in the exhibition area for you to try out and see for yourselves to see if the comments I have been making are true for you as well. When we make presentations of our activities to teachers around Britain, I always end by urging them to try out the systems, programs and materials themselves, for only in that way will they begin to appreciate how effective they are. May I give the same encouraging message to you.

I want to end where I began. The speed of change in our society is accelerating and microelectronics in its various manifestations is one of the more important instruments of that change. In my view, we have to help prepare our children now in the midst of these changes, not wait for society to settle down. To tinker with the subject is to miss the boat, for the changes deeply affect the curriculum of all our children. We have set out in a co-operative venture, government, my Programme, commerce and business, teachers and children, all trying hard to work together. The problems we are facing and trying to solve are the same throughout the world, even if the language is often different. I hope you will all join in with us in preparing our children for the Information Age.

Richard Fothergill
Director

Microelectronics Education Programme
June 1983

Title

Conference Paper: Production and Distribution of Programs for Databased Education

The Developments in Britain The Microelectronics Education Programme

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The purpose of this paper is to outline the main activities of the British Government's "Microelectronics Education Programme" and to explain a little of the pedagogy which is behind our present use of microcomputers and microelectronics in British schools.

I will begin by describing how the Microelectronics Education Program has been set up and organised, and then will describe our present thinking about the types of materials and the various methods of teaching that have evolved through our experiences in using microcomputers in schools.

In 1980 the British government announced a project for education to meet the challenge of the new technology, Richard Fothergill was appointed to lead what has become known as the Microelectronics Education Programme or MEP. While initiated by the government through the Department of Education and Science and receiving its funds from it, the Programme has been given a relatively free hand to approach the problems in its own way, and that sense of independence continues to be very important in encouraging teachers to work closely with us. After a preparatory period the main part of the Programme got under way in April 1981. MEP formulated two main aims to guide our decision-making for the activities we were to initiate:

(a) to help children understand the technology, its uses and its effects on society, and,

(b) to encourage teachers to use the technology in improving the effectiveness of their teaching.

This means that all curriculum subjects will be affected by our activities, not just science and maths, of course, but also history, geography, music and English and many others too. Likewise, the Programme is providing for children of all ages, from five years old to 18. Indeed the five to eleven year olds are some of the most responsive of all.

Therefore Microelectonics Education Programme is concerned with meeting its aims in all subjects of the curriculum and with children of all ages. In addition, it must be emphasised that it is also concerned with children of all abilities. As we are not concerned solely with turning children into bright computer scientists - we are not targetting our work on the clever children alone. Rather, this is for all children, for all are going to live in a world influenced by this new technology and they all need to adjust to it. It is also true to say that computer technology can bring out abilities, interests and enthusiasms which have been ignored by other areas of study, particularly in work with the technology itself.

There are over 400,000 teachers in Britain, and the question we faced was how to reach them all and enable them to participate in the work of the Programme. You may be aware that in Britain whilst there is a government department which gives guidance on education, the actual schools and teachers are organised by 102 local authorities, each with an independent viewpoint. With their co-operation, (a word you will hear many times in this paper) we have organised them into 14 regions for the purposes of the Programme. This has given us the opportunity to get closer to the teachers in every part of the country for there are MEP activities scattered around in every one of these regions. Thus, the innovative strategy that we have adopted is based on encouraging teachers all over the country to join in a campaign of action. Many are working directly for the Programme, while others are using its materials or taking part in training courses. All have a national direction, amended locally to meet the particular needs of the area in which the teachers live.

More of this in a moment. Thus the strategy is based on an almost even division between activities that are initiated and controlled nationally by the

directorate of the Programme and those that are operating in the regions to a nationally set list of aims, and monitored and co-ordinated by the same national leadership. To make this succeed, it requires a coherent plan and a co-operative approach.

The regional activities are divided into three parts. First, there is the Information Centre with staff to issue newsletters, show visiting teachers equipment and a wide variety of teaching materials in many media, help them over their problems and give them instruction, but above all keep them well-informed about curriculum developments and new software and devices in their subject areas.

Secondly there is an in-service training programme for teachers in all subjects and at all levels. This Programme is divided into four domains which I shall describe later, and in a typical year of operation, over 20,000 teachers have been on the courses offered. These range from one to ten day courses. Each is run in the region by regional staff so that local needs and interests are covered but the main elements of the courses are planned and developed by national co-ordinators. The aim is to concentrate on teachers in the regions who will become trainers themselves and then go on to train their colleagues - so that the whole approach cascades down from the national initiative to the classroom itself. It is difficult to account accurately with this method of training but a rough estimate suggests that over 70,000 teachers will now have met some training from this approach. As for those regional staff, they too go on regular updating courses to keep them abreast of the latest developments and new materials.

The third of these regional activities is curriculum development, the preparation of new computer programs and other teaching materials, again arranged to a clear national plan of needs. This builds on the natural skills of the teachers and advisers in the regions who know what they want in the classroom, and thus here are more small groups of people involved in MEP work and generally supporting and spreading its message around the country. This increases widely the number of educationists who are co-operating with us to ensure the work succeeds.

Each of these three areas of activity are mirrored in national projects as well. Thus we provide central information in newsletters and on electronic systems

like our word processor discs which go out for our word processor network. Each of our regional centres has a Diamond word processor which can link through the telephone system to the others. We also use an interacted Electronic Mail service too. This standardisation means that all the centres can share information, exchange discs of databases and make use of regionally produced information sheets, which they can personalise and print without major retyping. In addition, MEP has many pages on Prestel, the national viewdata system which schools are increasingly able to access through their computers.

For in-service training, we have a considerable project being prepared by the Open University. This will generally reflect much of the in-service programme and will be particularly valuable for those who find it difficult to attend courses or who are not very happy about attending them. The national software development units are now well established, and more are being created. They produce large numbers of computer programs, again to a national plan of work, and they reach very high standards of quality and classroom value. The important point about all these programs is that they are carefully planned with teachers much involved so that they fit the actual classroom needs.

Let me turn now to the coverage of the Programme and also its products to date. I am going to do this by talking about each of the domains in turn, but before doing so, let me re-emphasise the importance of the teacher training aspects. These materials and devices do not work to their maximum effect unless the teachers using them are trained in their value within the classroom situation. This is the conclusion from all our experience, and it is the reason behind all our emphasis on careful teacher training. One further point - all these domains do have overlaps with each other; but that is not a difficulty. It shows clearly the full curriculum pervasiveness of the technology and reflects also the well-established truism that one can approach a given piece of knowledge from several directions.

The first domain is electronics and control technology. In our view, all children must have some experience and understanding of this new technology so that they can deal with it in their future lives. This can begin effectively at 9 and 10 years of age, so that children begin to appreciate simple devices, the logic which arranges elements to perform specific jobs, and create them for themselves. This 'microelectronics for all' approach has led to some very exciting classroom work. Some is theoretical through filmstrips, simple kits and

videotapes, but children really get involved and reach understanding when they start making items. Some approach this through breadboarding with children knitting together circuits that work. Others start from carefully planned boards with inputs and outputs that the children can work on experimentally. Each leads to further understanding of the different ways in which the various elements can be linked to achieve different results, all in the process of using programmable devices to achieve particular controlled results. The end product may be traffic lights or it may be a robot arm, but the process is the same in both. From the skill point of view, the children learn the fundamentals of problem solving.

With this as a basis, children may choose to develop further knowledge of electronics and control, and further devices and teaching materials have been developed to enhance that work. On the other hand, they may wish to concentrate on other science and technology subjects.

Is it engineering and design? A computer program through which the children can design a shape, and then the computer can control a simple lathe and cut that same shape out of polystyrene.

Is it physics or chemistry? A new laboratory instrument which merges many separate measuring, monitoring and controlling devices in one to record and replay many experiments in a modern way and help the children draw real scientific conclusions.

Is it biology? Devices to monitor and measure temperature, humidity, movement and chemical change to reveal insights in the science of life, and display them in new ways. All the devices are microprocessor based; all help children develop understanding of scientific truths at the same time as absorbing the concept of control.

Our second domain is Computer Studies. For all children some understanding of how the computer works as a system, and the various elements of language and operation, are essential. There is nothing quite like using control to help children overcome initial anxieties and develop confidence. That is why we developed the buggy with its range of software to get children excited, but also through the range of programs to develop understanding of the elements of control and what the computer itself is doing. From this general background,

some children will move on to more detailed studies. A range of texts have been prepared to help them grapple with the computer as a system, simple programming and, most important, case studies to show its range of applications in society and in industry. Videotapes, books and case studies have been created to illustrate and deepen their knowledge of this all pervading device, above all giving them confidence and understanding of its use. As they get more experienced, more complex control options are opened up to them through kits. All provide a basis for stimulating interest in a career of computer science, but this degree of detail is only for a few. We do not believe that children should be trained as skilled programmers at this age. That seems unnecessary when languages themselves are changing as the power of the technology develops. It is helpful if they understand the principles of computer languages, but not to be tied down to the rigours of a particular one. Of course, some children will get carried away by the excitement and challenge of programming, and we do not wish to inhibit this. However, in terms of the curriculum itself, such activities are not an essential element.

I must add that the same comments can be made about teacher training. Our courses help teachers use programs, examine them to alter data statements, but we do not want them to become programmers. The best we look for is that they will be able to specify the content and approach of a program to meet a particular curriculum need.

Our third domain, computer based learning, is different again. Here we are concerned with computer programs that the teacher can use to help children learn any subject in the curriculum at any age. We have programs for 3 to 18 year olds. They fit any subject too, languages or science, music and art or technology. Before commenting on the types of program, let me just say how important we feel the packaging and presentation is to the teacher. The program must be capable of secure and safe storage under normal classroom conditions. It must also, and I want to stress this, have good, detailed documentation, not in the technical sense, but in the educational information it gives, for example objecives, age range, what the children must know before they use it, what they can go and do afterwards to consolidate and expand the learning that has taken place. MEP has prepared standards and guidelines for curriculum developers, software writers and publishers to help with the process.

The easy and natural response that teachers make towards the computer is that the programs can question and test knowledge, so-called drill and practice. Now, in our opinion, there is no reason why these should not be developed by a teacher for his own use, and various content free programs have been prepared to help them. That is material for the teacher to develop for the children in his particular classroom, not for a national Programme. These programs do not begin to exploit the exciting learning opportunities of the computer.

Instead our emphases are on simulations, models and conjectural programs, encouraging children to explore topics and how they work, and learn as a result. Children must be able to alter parameters or feed in their own ideas and react to the results by trying other approaches. They must draw conclusions and deduce concepts from these experiences. Exercises they undertake must bring out deductive thinking, exploit and manipulate the knowledge they have and force them in to decision-making routines. We want to encourage children to explore in the programs to different degrees and discover meanings. For the teacher, these cause more challenging thinking and pedagogic problems, for they mean that they have to help the children work and deduce through careful leading and judicious questioning, but the rewards at all ages are more excited and stimulated minds. The inarticulate learn to express themselves; the unaware find insights.

You will appreciate my enthusiasm. Screen design and the need for good graphics is obviously very important too as is the way the simulation works, but most important of all is that the learning psychology is right, and it is that with which we have taken care. While many of the programs are totally self-standing, it is interesting to see how teachers feel that a program is just one resource among others, and thus there is a great deal of associated learning going on away from the computers in other parts of the classroom, often with the children working in groups. The program is just one part of a total learning experience. MEP is much involved in developing these extra resources as well as the program itself.

Our fourth domain is communication and information studies. One half of its work is very obvious and clearly relevant, the understanding and use of word processing and other business studies work. We have developed materials which are specially designed for teaching purposes which can be used at any age. For it is already clear that teachers of many subjects find word processing for

themselves, and for the children they teach, can be very useful. Not only are we interested in the full keyboard as an input system for word processing, but we also want children to experience and use other methods of manipulating text, one hand keyboards for example. It is clear that the standard typewriter layout will be only one among many input systems in the future, and children must be prepared to accept these changes without any qualms or hesitation. Together with all other aspects of electronic communication systems which children will find a major feature of their future, this forms one part of the work of this domain.

The other part, and in many ways some of the most significant aspects of the whole approach of MEP, is the area of information studies. You will all be familiar with information retrieval systems, and the Programme has fostered several approaches. These range from a system for young children to more sophisticated work for the older ones. Much early learning is spent on the collection, organisation and presentation of factual information, and information retrieval systems are colourful and exciting ways in which children can get their facts together, overcome the boring bits of sorting and come rapidly to groupings which can lead to deductions, planning and thinking. In our opinion, this introduction can start at even four and five years, particularly with pictorial presentations of the results. When they get older, the systems have to be more complex, but then they are dealing with larger and more sophisticated bodies of information and looking for deeper insights and understanding. A database of a census can be very large, but the information that children can deduce from its rapid sorting can reveal very interesting and educationally useful knowledge.

This is still only the beginning. Large databases are increasingly on tap at the end of a telephone line. While each might have its own protocols, the principles of access and search are the same and these are what children need to appreciate so that they can cope with developments in the future. Their microcomputer is the terminal from which very large quantities of data can be accessed and explored as necessary. But the core of this work is the nature of information itself. What is it? How does it arrive? How is it created? What questions do we ask in order to get what we really need? Most important of all, what do we do with it when we have the information? These are the fundamental educational issues and we are now working hard on materials that help children work towards the answers. As will be clear to you, these are

issues that affect every subject in the curriculum, and so the work we do must help in each and every discipline. In the classroom itself, the changes will be profound, for it is not the information-giving role that will be the main purpose of the teacher but rather the information-using aspects. This is a change to the core of our understanding of the purposes of education.

Those then are the main domains of the Programme, each approached broadly and affecting all aspects of the learning environment and all parts of the curriculum. One further sector is receiving much attention, and that is special education. I had better explain what is meant by that. A number of children are slow learners or may even be mentally backward, and a small number suffer from physical handicaps, blindness, deafness or muscular problems. All these collectively are educated through special education schools or units. Programs for them work at a more patient and lower level of sophistication, helping them to practise skills and re-inforce knowledge that they have gained. A number of programs have been developed for these children, and some of those aimed at younger children can be specially adapted. MEP is also working with some simple devices to try and help these children manipulate and work in their environment. This is important if they are going to be able to fit into normal society and communicate comfortably and naturally with other people. The power of the products of the technology can be very helpful indeed in this area.

The approach to special education is the same as the rest of the Programme. We have information centres called SEMERCs that keep teachers informed and provide exhibitions of ranges of appropriate materials. They are also involved in stimulating co-operative work between the teachers. There are also teacher training activities which help to brief the teachers and keep them up to date with the latest developments, and also there are projects throughout the country where materials and devices are being conceived, created and tested in the classroom. The number of children who need this help is not very large, but the affect on them, their ability to communicate, work and join in with the rest of society is profound.

I am sure you will have noticed that up to now I have hardly mentioned equipment. Only in the electronics domain has it figured significantly. The theme of the Programme has been to answer the questions that have been posed by educational needs, the requirements of teachers and the curriculum initiatives that have underwritten them. However MEP has not ignored the equipment

side, and by working in co-operation with another part of the government, the Department of Trade and Industry, it has encouraged the distribution and use of computers.

Three major schemes are now complete or under way to help schools purchase equipment, all of them involving government funding of half the price while schools have paid the other half. Only one computer or peripheral system has been on offer to each school in this way and they have been able to choose from two or three British machines, Research Machines, Acorn/BBC and Sinclair, all of which are available throughout the world. The programs we have written work on these machines, but many are also available on Apples and Pets. Our ethos has been to write for one machine and rewrite for the others so that the programs take advantage of the particular specifications that each offers. In school use each of these computers has proved very successful and now networks are being established between groups of them. While the government offer only referred to one machine, the impact has been very considerable. Schools for the 11-18 year olds have at least five now and several have 20 to 30 computers, while the smaller schools for the seven to 11 year olds have one to two. Considering that resources for schools are limited, this is a very rapid uptake in a period of about only two years. Teachers must feel they are important and useful to have put such a priority on obtaining the equipment.

In supporting the issue of this equipment, MEP also produced in-service training packages to go with them. Teachers not only made use of these materials to help them understand the equipment but they also went on courses of two to four days to discuss and work with them. Under the INPUT Pack (11-16 years) training scheme some 12,000 teachers have been trained. For the Microprimer (5-11 years) Scheme, (which has only just started) already some 15,000 teachers have participated in courses. You will notice the wide range of materials in these packages, books, machine guides, audiotapes, overhead transparencies, tape slides and of course computer programs. The tutors who take the courses that the teachers attend also have carefully prepared kits of materials to use in their own personal way but based on a carefully designed national scheme.

Thus the Programme has been developing approaches, teaching and learning materials, and equipment. The final element in the complete impact on the school is the classroom itself, and we have been working here as well. A computer classroom is not just a place where children learn computer studies

and are taught by a teacher dictating knowledge. It is a place where children can come and explore all the many ways in which this equipment can support learning in very many subjects, and thus such a classroom should be completely re-arrangeable, open-ended and exploratory. The design we have established meets all these requirements and provides a pleasant and exciting atmosphere in which to learn.

In a paper of this length, it is not possible to give more than a hint of the philosophies behind the MEP operation. We are obviously producing great quantities of tried and tested materials in a wide range of subjects and media, and in doing so, we have set a large number of wheels in motion for more and more such projects. In what I have discussed, and in the pictures I have shown, you have been given a small taster of the operation. I hope you have gained the impression also that all this work, although funded and sponsored from government funds, is firmly based in the curriculum and teachers needs in meeting the learning requirements of children. There is a carefully plotted and coherent set of plans for the development and production of these materials which fit certain curriculum aims and these are nationally developed. The important issue for the teachers is that they can add to this approach and interpret it in a style which fits the particular group of children with whom they are working.

You will have noticed also that the Programme is comprehensive. We came to the conclusion, early on, that it was not sensible to concentrate on only one aspect, computer studies for example, for the impact of this technology was pervasive throughout the curriculum just as it is throughout society. It was also producing major changes in the way in which subjects could be approached and learnt, and in the attitudes of the children. So you will have seen that we have covered all ages and all subjects. We have also interested ourselves in the teachers, the curriculum, the materials, the equipment and even the classroom. Affecting one without involving another aspect again means that you omit areas that could well prove to be the final constraint in preventing a teacher taking the value of the technology into his work.

At the beginning of this paper, I mentioned the word co-operation and I want to return to it now. While the Programme itself is a nationally directed operation, you will have gathered that the work is a joint participation between the teachers, our regional staff, many small working groups and the national

directorate. It is not just focussed around the capital London - indeed the directorate is based in the North of England in Newcastle - but involves the whole country. Nor are the projects themselves only funded and supported by the education system. We have many joint activities with large and small companies in all parts of our work, another example of co-operation. To distribute and market our products, we have worked with many other commercial concerns, both large and small, publishers, manufacturers and software houses. They are co-operating with us in taking the materials, packaging them in our styles and distributing them all round the world. We too are working with other companies who have developed their own products, and where we think them of value, we are putting them in our information centres and on our courses and discussing how effectively they can be used.

This sense of co-operation has transformed the efforts of the Programme and made it possible to penetrate deeply into the heart of the education system. By involving many different enterprises and people, interest in the work of the Programme, and more especially committment to its aims and objectives are promoted throughout the country. This is a very useful and successful method of ensuring the propagation of an innovation. The more widespread the network of people the more likely that the effort is diluted and this means more careful control and monitoring, but, at the same time, the more people feel they relate to the work being done and therefore take it into their teaching. We also have to be realistic in our targets. A good supportive approach of co-operation with teachers and educationists does provoke a groundswell of spreading interest, but only those who are willing to allow themselves to be involved will take notice of it. Others will ignore the signs and continue in the same way that they have done for years, and they will not change, just as many other people in society.

The essential point is that we have started the process of change amongst our teaching force, and in our schools. That process will only continue if sufficient of our colleagues also believe that the changes are educationally justified too. We consider that we have passed the critical point, in terms of the provision of equipment, materials, and teacher training. We have produced a great 'thirst' for computer-based-learning in Britain (and possibly other countries too). We must now strive to enable others as well as ourselves, to meet the demands of these teachers and schools.